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High density planting - an option for higher productivity of *Hevea brasiliensis* in north eastern region of India

S.K. Dey* and B. Datta

Rubber Research Institute of India, Regional Research Station
Kunjaban, Agartala - 799 006

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Abstract

The effect of planting density in rubber (*Hevea brasiliensis*) was studied in an experiment conducted with three densities *viz*., 420, 620, 824 trees ha^{-1}. It was observed that lower density had higher percentage of trees ready for tapping during initial years, due to better growth. However, higher density achieved required girth in subsequent years. In spite of decrease in plant number over the years, the highest density had always lower girth even after 24 years of planting. Higher density also has higher percentage of too small trees, not suitable for harvesting latex. The higher plant densities resulted taller plants, increased crotch height and decreased the number of branches and thereby plant density affected yield per tree and yield per unit area. Though the yield per hectare increased with increased plant density during initial years, however declined later period. High yield per tree per tap was observed in the lowest density with lower yield per unit area. Yield increased in all densities with application of stimulant. Percentage of yield increase due to application of stimulant was higher (40%) in medium density (620 trees ha^{-1}) compared to other plant densities. Percentage of wind damage was lower in high density planting during initial years. Total timber volume per hectare was high in higher planting density and lower per tree volume of log compared to lower density. Maintaining a density of 620 trees per hectare appears to be most suitable for north eastern region of India.

Keywords: Growth, *Hevea*, high density, timber volume, yield

Introduction

The search for a stand density to maximize productivity of rubber has continued since the beginning of the plantation industry. Density is one of the few parameters that can affect the productivity of rubber. High density planting is one of the options to reduce wind damage (Roy *et al.*, 2005; Dijkman, 1951). Report also showed that planting density had no link with wind damage (Obouayeba *et al.*, 2005). Effect of high density planting in rubber is well documented in literature (Westgarth and Buttery, 1965; Obouayeba *et al.*, 2005; Roy *et al.*, 2005). Plant density is one of the major factors in crop production and varies depending upon other parameters. However, growth and yield were strongly influenced by planting density in rubber (Dey and Pal 2006; Varghese *et al.*, 2006).

The rubber cultivation is being extended to north eastern region to reduce the gap between demand and supply of rubber. The north eastern states have great potential for natural rubber cultivation. The crop has gained popularity due to its easy adaptability and high return. This region have 1,01,685 ha rubber in 2009-10 (Rubber Board, 2011), however, more than 80 per cent of holding are in small holding sector with an average holding size of one hectare. Loss of trees due to high velocity wind is prevalent in this region. A small holder is always intended to have high density planting to improve the productivity of his land. An experiment on high density planting of rubber was conducted with an objective to study the long term effect of density on growth, yield and other associated parameters.

**Corresponding Author: dey@rubberboard.org.in*

Materials and methods

The experiment was laid out during 1988 at the experimental farm of the Rubber Research Institute of India, Regional Research Station, Agartala, at Taranagar (91°15'E; 23° 53'N; 30 m above msl) in split-plot design with four replications. Three densities, *viz*., 420 (D1), 620 (D2) and 824 (D3) trees ha^{-1} square planting of 4.9 m, 4 m and 3.5 m spacing respectively, were imposed as main plot treatments while three fertilizer combinations of N, P_2O_5 and K_2O were the sub-plot treatments. A popular clone, RRII 105 and a fast growing clone, RRII 118 were used as sub-subplot treatments. The gross plot size was 595 m^2. The number of plants accommodated in a plot was 25, 36 and 49 for D1, D2 and D3 respectively. Fertilizers were applied in two equal doses as pre- and post-monsoon applications. Since the fertilizer treatment was non-significant over the years (Roy *et al.,* 2005; Dey and Pal, 2006), the fertilizer factor is not discussed in this paper. The yield was recorded for ten years after opening of the tree and the growth was recorded for 25 years. The girth of plants was recorded at a height of 150 cm from bud union. The yield of individual tree was recorded following cup coagulation method. Tapping was initiated during 1996 adopting S/2 d3 6d7 system and after four years it was changed to S/2 d2 system for next three years. Subsequent years, trees were tapped following S/2 d3 system of tapping with stimulation and two months annual tapping rest during February and March. The trees were rainguarded and 2.5 per cent ethephon (2-chloroethyl phosphonic acid 17.5 *a.i.*, mg tree^{-1}) was applied three times in a year for yield stimulation on the BO2 panel. Wood produced has been expressed in volume as cubic meters (m^3). The per tree timber volume was estimated by using full circular volume ($g^2/ 4\pi$) x l.

Climate of this location is warm perhumid (Sehgal *et al.,* 1992). The mean annual rainfall of the location during last 27 years was 1902 mm. The mean annual temperature was 25.3 °C, the maximum and minimum temperature were 30.6 °C and 20 °C respectively. Average annual sunshine hours and relative humidity was 6.2 hr day^{-1} and 77 per cent respectively during the period.

Results and discussion

Growth characters

Increasing plant density had decreased plant girth and this trend was continued over the years (Fig. 1). The girth increased with increase of age and the difference of girth among the densities was maintained. As the number of plants is more at higher density, the plants developed more compact and smaller crown compared to plants in lower density plots. Inter plant competition reduced the rate of plant growth and consequently low growth in denser planting. Effect of closer plantings on growth was evident from as early as the fourth year (Devakumar *et al.*, 1995) and higher density resulted in smaller crown (Westgarth and Buttery, 1965). Growth of plant was adversely affected when plant number exceeds 549 trees ha^{-1} (Varghese *et al.,* 2006).

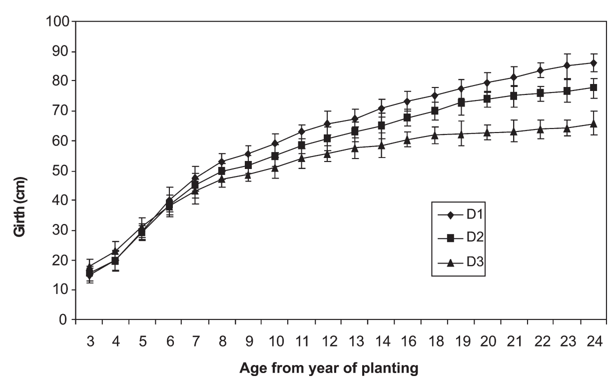

Fig. 1. Effect of density on girth

Crotch height is the vertical distance from ground to first branch developed on trunk, which increased with increase in density. Higher density showed higher crotch height (2.83 m) as compared to medium (2.57 m) and low (2.54 m) densities. Higher number of main branches were observed in lower density (3.34) and lowest in highest density (2.42). Girth of main branch was in reverse order of 39.3 cm, 36 cm and 31.5 cm in D1, D2 and D3 respectively. Denser planting resulted in narrower crown and higher crotch heights (Webster 1989; Devakumar *et al.,* 1995). Due to intense competition for height, plants at higher densities tend to become lanky and contribute to a higher crotch. Closer spacing tend to higher self pruning of lower branches resulting in taller trunks (Zongdao and Xuegin, 1983). Usually, the trees tend to grow taller and thinner in order to harvest more sunlight (Webster 1989). The plant density affected the plant height in the early years (Mainstone, 1970; Devakumar *et al.*, 1995) however, the effect disappeared during later years (Mainstone, 1979; Dey and Pal, 2006). Competition between plants generally observed after canopy closure (Ng, 1993). Plant density had little effect on leaf area index after closure of canopy (Dey and Pal, 2006).

It was observed that higher density had lower percentage of trees ready for tapping per unit area (Fig. 2), whereas lower density had thicker virgin bark (7.68 mm) compared to the denser (7.2 mm) planting after eight years. Thinner virgin bark in lower planting densities was reported by Rodrigo *et al*. (1995). The effect of planting density on proportion of small trees is very apparent. The too small tree not suitable for tapping was 2 per cent for lower density (D1), 6 per cent for medium density (D3) and 10 per cent for highest density (D3). Higher density increases stand biomass capable of growth and makes trees grow taller in proportion to diameter and decreases the rate of growth of each tree, which takes longer immaturity period and delay in production. The number of tappable trees did not vary much with density of planting in clone PB 235 in south western Cote d'Ivoire Africa (Obouayeba *et al.*, 2005).

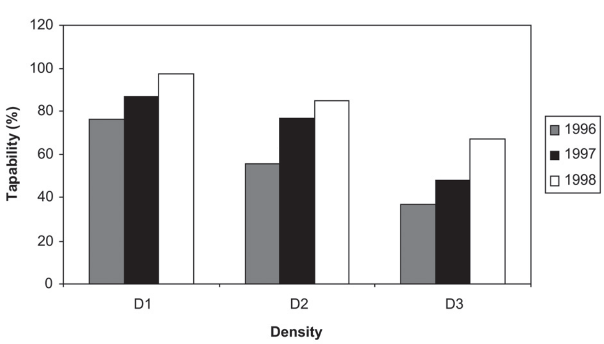

Fig. 2. Effect of density on percentage of tapability

Yield parameters

Plant density affected yield per tree and yield per hectare. Higher average yield per tree per tap (46.2 g t^{-1} t^{-1}) over ten years was observed in the lowest density compared to higher density (33.2 g t^{-1} t^{-1}) (Fig. 3). Plants in dense planting were smaller in girth which has contributed lower yield

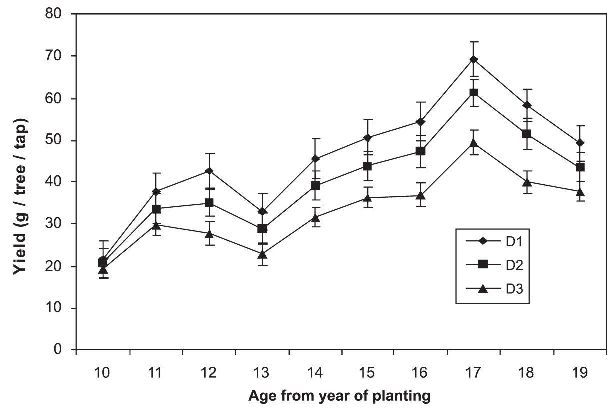

Fig. 3. Effect of density on yield per tree per tap in different years

per tree. Yield per hectare increased with increasing plant density for initial years. Subsequent years the yield was at par with medium density and declined later year (Fig. 4). The yield per tree per tap was negatively related with increasing plant density whereas, yield and girth were positively related and higher density had high cumulative yield (Westgarth and Butery, 1965). Yield stimulant (Ethephon) is being used to increase the productivity of rubber. It was observed that yield increased in all densities with application of stimulant (Fig. 5). However, the percentage of increase was more in medium density compared to other densities.

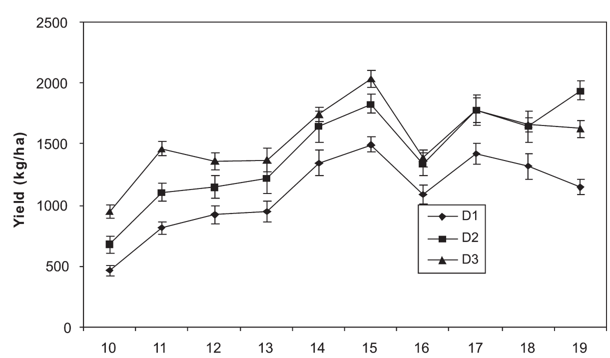

Fig. 4. Effect of density on dry rubber (kg ha^{-1}) in different years

Wind damage

Strong wind in different years had damaged the rubber plantation in this region. It was observed that plantations with lower densities had more damage compared to higher densities in different years (Fig. 6). Progressive decrease in number of trees per unit area was observed in all densities. The

Fig. 5. Percentage of increase in yield ha^{-1} over control (unstimulated) due to application of stimulant

control of density in wind prone area is not possible in the mature stage of rubber, which not only reduces the plant number per unit area but also reduces the dry rubber yield. It was observed that each time the plants in the higher density had less damage due to branch snap as compared to lower density planting. More wind damage was reported in lower density and reduced incidence of wind damage by increasing the density (Dijkman, 1951). The planting density recommended for wind prone areas of China is 630 trees per hectare (Zongdao and Xuegin, 1983). Major loss of trees due to disease was not noticed in early years, however, few incidences of brown root disease was noticed in the later years, which decreased the plant numbers in highest density plots.

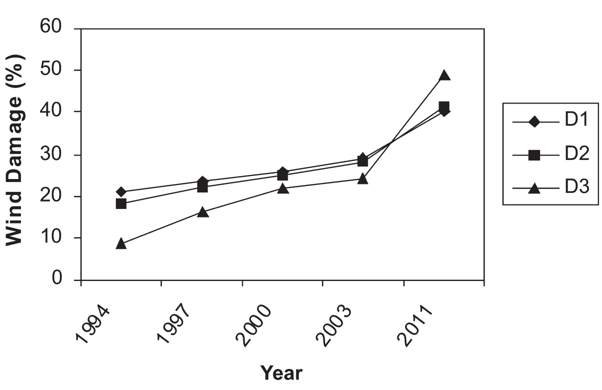

Fig. 6. Percentage of trees damaged due to wind damage in different densities in different years

Total timber yield of a tree may be regarded as an additive function of the stem wood as well as branch wood, which are known as bole volume (stem wood) and canopy volume (branch wood) respectively. The proportion of available stem wood is reported to be 60 per cent and that of branch wood 40 per cent in India (Joseph and George, 1996). The volumetric timber yield of *Hevea* logs varies with density. Average bole volume of 25 year plantation is around 68 m^3 ha^{-1}. The bole volumes were 75.4 m^3 ha^{-1} for higher density, 67.7 m^3 ha^{-1} for medium density and 59.9 m^3 ha^{-1} for lower density. However, bole volume per tree was in reverse order. An average timber yield of 157 m^3 per hectare of 29 year old rubber plantation has been reported in Kerala region (Viswanathan *et al.*, 2003). In Malaysia, commercial high density planting at 800 stands ha^{-1} of clone PB 260 had shown the vigour of tree growth until the age of four years. The juvenile timber from thinning of these trees is being used as raw material for conversion into particle board, medium density fiber board and other suitable panel products (Ghani and Abdul Kader, 2000).

During the initial stage of trees high density planting did not show any marked effect on girth. As the competition between plants intensified, the plants at higher densities were observed to be in poor growth which affected the percentage of trees attaining tappability, with sufficient bark thickness followed by lower yield per tree. Increase in yield per unit area was uncertain beyond 620 trees per hectare. In general, high dose of fertilizer gives higher growth. High dose of fertilizer did not improve the growth in high density planting in mature stage (Roy *et al.,* 2005; Dey and Pal, 2006; Varghese *et al.,* 2006). It appears that light is the most limiting factor for growth. Additional fertilizer applications have no effect on denser planting. However, higher initial density of planting reduces wind damage and also help in better establishment of the plantation in the early stages.

At optimum stand density where there is complete canopy closure, the growth and yield of rubber is expected to decline. Density of real stands fluctuates around a certain equilibrium level and may approach the maximum during favorable growth conditions when most of the canopy gaps are closed. However, wind damage causes the canopy gaps and change of plant number per unit area is being continued. Yield per hectare varied relatively little over quite a wide range of planting densities (Webster 1989). Optimum trees per hectare for rubber were advocated by different authors in different countries such as 625 trees ha^{-1} for Thailand

(Jarin and Somyot 1996), 650 trees ha^{-1} for south western Cote d'Ivoire Africa (Obouayeba *et al.*, 2005) 630 trees ha^{-1} for China (Zongdao and Xaegin, 1983). In the present observation 620 trees appears to be optimum for north east region of India.

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